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Lessons learned from the patrol hydrofoil missile (PHM) program

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THESIS

Lessons Learned From the Patrol Hydrofoil Missile (PHM) Program

by

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suggests that factors inherent to the current systems acquisition process caused the cut back in the program and that these were independent of the program manager's efforts. The results of the analysis suggest that these factors have the potential to affect the outcome of any acquisition program, no matter how well the hardware performs.

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Lessons Learned From the Patrol Hydrofoil Missile (PHM) Program

by

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ABSTRACT

The PHM project began as a major NATO acquisition program consisting of 60 or more ships for international purchase. Today the program consists of just six ships for the United States alone. This thesis reviews the history of the program, the design considerations and the current problems experienced by the program manager. An analysis of the rationale behind the decisions which led to the reduction in scope of the program suggests that factors inherent to the current systems acquisition process caused the cut back in the program and that these were independent of the program manager's efforts. The results of the analysis suggest that these factors have the potential to affect the outcome of any acquisition program, no matter how well the hardware performs.

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I. INTRODUCTION

A. BACKGROUND

The U. S. Navy's Patrol Hydrofoil Missile (PHM) ship is a defense application of a relatively new hydrodynamic concept. Previous hydrofoil ships using fixed foils which conform to the water's surface like water skiis have great speed, but their use is restricted to calm seas. This limitation makes them unacceptable for use by the U. S. Navy.

The latest version of hydrofoil ships utilizes forward and aft submerged foils which in a sense "fly" through the water under the surface much like airfoils through the air. The moveable trailing edges of these foils are continuously adjusted by an automatic control system fed by signals from acoustic wave height sensors. As the foils adjust to the wave size, the result is a stable ride in almost any sea state. The forward foil system, in addition, includes a fully swivelled strut that provides directional control and allows the ship to bank into turns giving the ship a high degree of maneuverability. The foils and struts, both fore and aft, are retractible to permit hullborne operation with reduced draft restrictions and to facilitate access for inspection and maintenance.

Use of this advanced hydrofoil technology in the PHM program has resulted in a warship capable of speeds in

excess of 40 knots in virtually any sea state. Furthermore, it is designed to NATO standards and can be easily adapted for individual use by any NATO nation or cooperative multi-national use in a NATO Task Group.

Considering the fact that the ship does everything it was designed to do and that its potential contribution to naval seapower is extraordinary, one is lead to believe that a program to build a fleet of such ships might be a worthwhile undertaking. In fact, the PHM was a major project at one time with planned production of at least 60 ships for multi-national purchase. Today, the PHM program consists of just six United States Navy ships (one operational prototype and five currently under construction). How such a promising and exciting program could undergo such an extreme reversal is intriguing and warrants investigation.

B. PURPOSE

This thesis reviews the chronology of the PHM and analyzes some of the major historical events in an attempt to discover the reasons for such a reduction in scope of the program. The analysis suggests that factors in the systems acquisition process external to the program manager's span of control were responsible for the cut-back.

C. SCOPE

Data and information were obtained through research of published literature, PHM logistic plans, Congressional

testimony, interviews with personnel involved and a one-month experience tour at the PHM project office in Washington, D. C.

In a non-technical approach, the chronology describes all the major events to date in the program including the considerations which contributed to the final design. Current acquisition policy, procedures and environmental factors evident in the PHM program will be analyzed in terms of their potential to affect any weapons acquisition program independent of the program manager's executive ability.

II. CHRONOLOGY OF THE PHM PROGRAM

A. EARLY CONCEPTS

In mid-1969, NATO Commanders expressed the need for ships to combat the threat posed by Soviet surface combatants in the coastal and narrow seas environments of Northern Europe and the Mediterranean Sea. Later that year, a sub-group of eleven NATO nations from a NATO Information exchange group met to discuss the requirement. In early 1970, NATO Exploratory Group Two was established to study the concept of a common fast patrol craft.

Each nation recognized the potential benefits of a cooperative program. Not only was this an opportunity to upgrade their defense capabilities at relatively low cost, but also, a single ship class for use by all NATO allies would enhance the capability of a NATO Task Force from both operational and logistics points of view. The United States

hoped for the additional benefit of being able to reduce its NATO commitment to the European area as those countries improved their own naval capabilities.

Prior to the establishment of Exploratory Group Two, the United States had designed, built and tested four hydrofoil ships: HIGHPOINT (PCH-1), 120 tons, delivered in 1963; FLAGSTAFF (PGH-1) and TUCUMCARI (PGH-2), 60-70 tons, in 1968; and PLAINVIEW (AGEH-1), 310 tons in 1969. As of November 1972 these craft had accumulated more than 2700 hours of foilborne operations [1]. This experience made it clear that proven technology existed in the United States, and that submerged hydrofoil platforms would be a feasible low-risk venture [2].

The United States, therefore, proposed a 40-ton submerged foil craft as the most suitable means of meeting the NATO mission requirement because of its speed and maneuverability in high sea states. Exploratory Group Two concurred with this proposal, as did the NATO Naval Armaments Group who subsequently approved the establishment of Project Group Six to conduct the planning stages of the program and the initial determination of the ship's characteristics. The United States logically assumed chairmanship of Project Group Six and sponsorship of the program.

Through June 1971, the United States conducted further hydrofoil baseline design studies and cost estimates. These design data provided for the operational performance agreed upon by Exploratory Group Two and incorporated previously

expressed national requirements. At a June 1971 meeting the United States agreed to produce two PHM lead ships if a design satisfactory to at least one other NATO nation could be achieved. At that meeting it was also mutually agreed that active participants of subsequent meetings would be limited to those nations who had formally declared their intent to proceed with the cooperative hydrofoil project and, subject to an agreed Memorandum of Understanding, to formally enter the program as an "engaged" nation and commit resources thereto. Letters of intent were eventually signed in early 1972 by the Government of Italy and the Federal Republic of Germany.

In October 1971 the United States announced its intentions to award the lead ship design and production contract to the Boeing Company, builder of the HIGHPOINT (PCH-1) and TUCUMCARI (PGH-2), and that the initial effort under the contract would be feasibility design studies. The objective of these studies was to obtain clear agreement on a specific common ship design which would satisfy all engaged nations' requirements. Further, due to the advance in program schedule without having yet obtained a satisfactory Memorandum of Understanding, the United States indicated it would proceed at its own expense with the NATO design, share the results of these studies with all engaged nations, with costs to be reinbursed only by those engaged nations who later signed the Memorandum of Understanding, and to conduct all aspects of the design

development, contract definitization and management in cooperation with the engaged nations.

The letter contract was awarded to Boeing in November 1971. Feasibility design was completed in March 1972, and a Memorandum of Understanding was signed approximately six months later by the Government of Italy and the Federal Republic of Germany. Because of unwillingness to commit funds all other nations either dropped from the program or reverted to observer status with the option of rejoining the project at any time pursuant to approval by the original three committed nations.

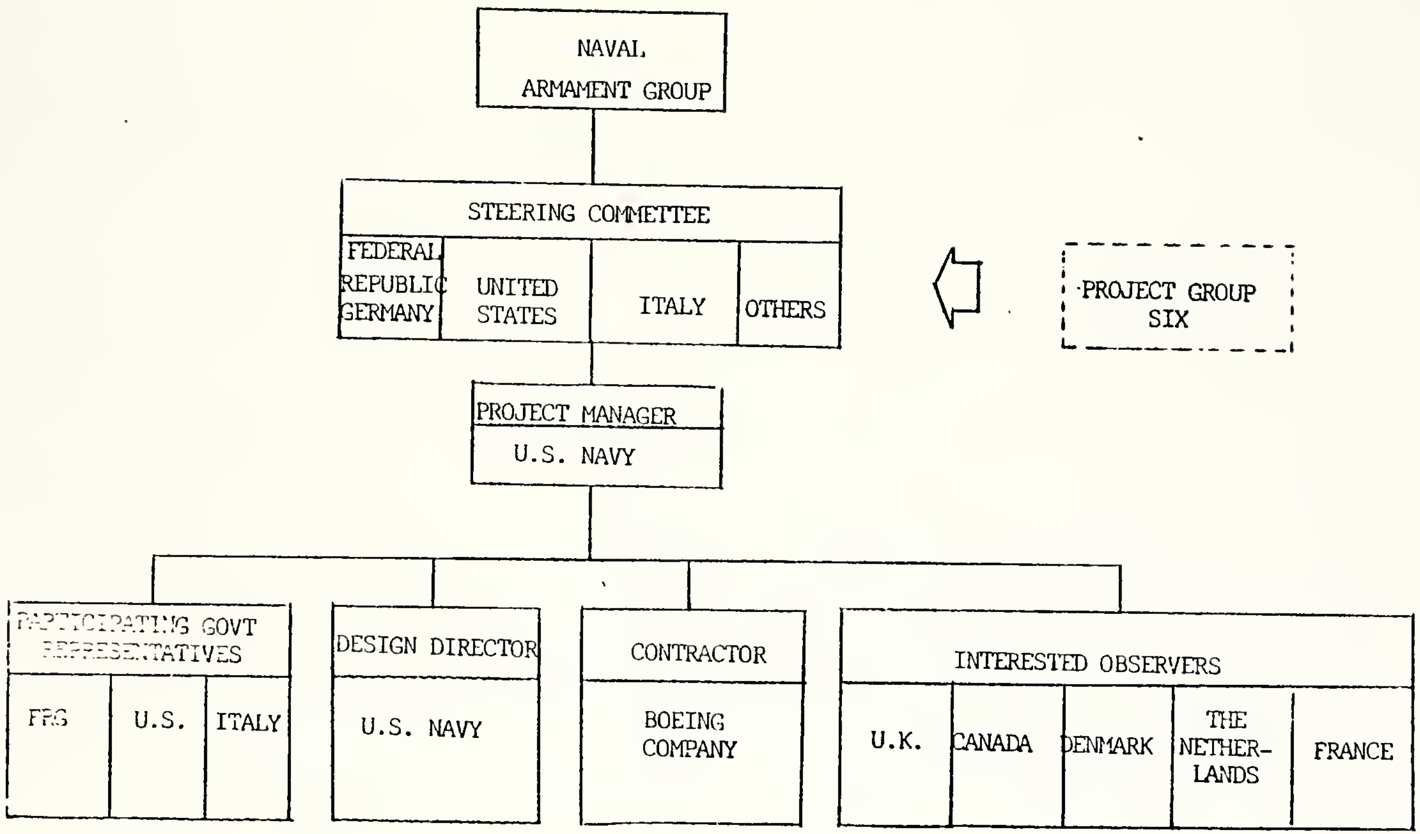
1. NATO PHM Organization

Upon signing the Memorandum of Understanding, a permanent Steering Committee composed of senior representatives of each participating nation was formed. Each member was responsible for the necessary coordination with appropriate authorities of his own country. Changes in technical approach, cost or schedule which would have major impact required unanimous committee consent.

The Memorandum of Understanding provided for the initial chairman of the Steering Committee to be the United States member. In addition the Memorandum of Understanding provided for a NATO Project Office to serve as the executive staff of the Steering Committee to perform the complex management functions associated with ship design, construction and logistics programs. The United States was

TABLE 1

NATO PHM PROJECT ORGANIZATION



designated to provide the Project Manager. (See Table I for Project Organization Chart.)

2. Costs

In achieving the objectives of this cooperative effort, the participating nations shared design and non-recurring prototype construction costs. These costs included the cost of developing the standard ship design (to be discussed later), design validation and operation of the administrative project staffs. The Memorandum of Understanding specified exact dollar commitments for each country but did not include a cost escalation clause.

Production cost savings were expected to be realized by the mass production of all ships at a single plant. Cost benefits were expected to accrue from assembly line production in great quantities, and proportionate sharing of fixed production costs would lower the unit cost per ship for each country [2].

B. DESIGN CONSIDERATIONS

A ship is designed to perform a mission. Capability to accomplish a mission depends not only on the operational capability of the hardware, but also on the ability to logistically support it. Therefore, a ship design is the end result of an iterative process which attempts to optimize mission capability by making trade-offs between operational and logistics capabilities. What follows is

some of the operational and logistics support considerations which produced the final PHM design.

1. <u>Operational Considerations</u>

The mission scenario required the PHM to be capable of operating offensively, either independently or in company with PHMs from the same or different countries, against enemy surface combatants in coastal and narrow seas environments. It had to be capable of performing this mission during patrols of up to five days. A minimum of two days upkeep would be necessary between operational periods [1].

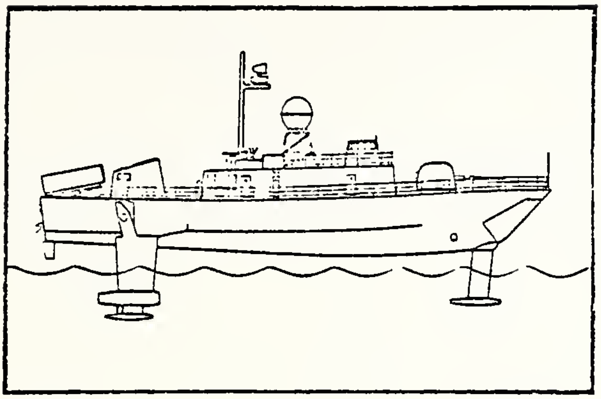
a. Standard Ship Design

It was recognized during the early stages of the ship acquisition process that a single version of the PHM for use by all nations was not likely. However, to assure the effectiveness of their operation together within a NATO Task Force, it was desirable that the individual national PHMs have similar basic characteristics. To achieve this objective, a standard PHM ship was designed for multi-national use yet retained sufficient design flexibility to allow for the individual variations of any country particularly in the area of combat systems equipment. The standard PHM has characteristics as indicated in Table 2 [1].

The hull form, size and the major structural bulkheads and decks, foils and struts, waterjets, pumps,

TABLE 2

STANDARD PHM CHARACTERISTICS



Length	40.0M
Beam	8.6M
Draft	
Hullborne	1.9M
Foilborne	2.7M
Displacement	235 Metric Tons
Speed	
Hullborne	11 Knots
Foilborne	In excess of 40 Knots
Propulsion	
Hullborn	2 Diesels
Foilborne	1 Gas Turbine Engine
Foilborne Range	500 Nautical Miles

controls and main propulsion machinery are part of the standard PHM design. Additionally, the auxiliary equipment and arrangements, deckhouse and personnel accommodations are standard.

Due to weight restrictions and other considerations unique to hydrofoil operations, the PHM has a large percentage of equipments and systems which are not used on traditional combatants. These systems/equipments are listed in Table 3.

b. United States Variant of the PHM

Unlike the PHMs used by other NATO nations which would operate from a single home port, the U. S. variant had to be able to perform its mission anywhere in the world. In order to provide for global mobility, early logistics planners envisioned a hydrofoil support ship (AGHS) to accompany the six-ship PHM squadron to provide logistics support.

The primary weapons suite of the U. S. variant includes:

1 MK 75 76MM GUN
8 HARPOON MISSILE CANNISTER LAUNCHERS
1 MK 92 MOD 1 GFCS
2 MK 34 CHAFF LAUNCHERS

c. Country Variations of the PHM

The MK 75 Oto Melara 76 mm gun satisfies the mission requirements of all national participants. There is space aboard to equip a standard PHM with additional MK20 Rh 20mm anti-aircraft guns if desired. Standard ship

TABLE 3

PHM UNIQUE SYSTEMS/EQUIPMENTS

A. MB 8V331TC80 Diesel Engines (Mercedes Benz)

B. Waterjet Propulsors (Aerojet General)

C. Gas Turbine Ship's Service Power Unit (Airesearch)

D. AN/SLR-20 ESM Receiver (Litton Amecon)

E. Gyro PL-41E (LITEF)

F. High Pressure (3000 PSI) Hydraulic Systems (Boeing)

G. Submerged Strut and Foil System (Boeing)

H. Foilborne Automated Ship Control System (Boeing)

I. AN/SPS-63 True Motion Navigation Radar (SMA)

design flexibility permits the installation of various types of missile systems in place of the Harpoon system such as the Italian Otomat or the French Exocet. Fire control system alternatives include the German WM-28 and the Italian Argo System [2].

2. Balance of Payments Considerations

Since the PHM was originally a joint NATO venture it had a requirement for balance of payments equalization (offset) between all participants [2]. Each nation was thus assured that within reasonable limits, the value of components, materials and services it purchased from other participating nations would be offset by the combined purchases made by other nations from itself. The key objective of the cooperative effort was the effective utilization of the military, industrial, scientific and technical resources of the participating nations in terms of both men and materials, in the interests of mutual defense.

As a result of the foregoing, much of the PHM equipment is of foreign design or manufacture (e.g., the fire control system (Dutch), the 76mm gun and navigational radar (Italian), the gyro compass, air conditioning and diesel hullborne engines (German)). Furthermore, the PHM was designed and constructed using the metric system as the basic system of measurement to facilitate the interface of foreign equipments.

3. Manning, Maintenance and Training Concepts

A manning concept is a combination of the operational concept and the maintenance concept. It incorporates the quantities and skill levels of personnel required to operate and maintain a ship in its projected operational environment. Normally, U. S. Navy ships carry a crew large enough to perform all organizational level maintenance and operate the ship as well. The ship's manning document attempts to optimize the mix of operational and maintenance personnel.

The manning concept for the PHM differs from the standard Navy surface unit manning concept. To achieve the foilborne capability of the PHM, which is its primary operational asset, trade-offs were required in the size and weight of the vessel. Living space had to be sacrificed for engineering, performance and weapons delivery capability. Essentially the same traditional tasks must be accomplished aboard PHM, but they must be performed by less personnel.

To accomplish the reduced manning objective, functions previously requiring more than one watch station were combined into single watch stations. This was made possible by the development of automated equipment with built-in redundancy. Examples are the Helm and Engineering Operations watch stations.

The maintenance concept was also non-traditional. The complexity and numbers of the systems and equipments

of the ship required more maintenance personnel than the ship had the capability to support at sea. Furthermore, crew movement was restricted on weather decks during foilborne operations for reasons of crew safety, and, as a consequence, preventive maintenance could not be accomplished when foilborne. These conditions and the reduced operational manning concept motivated the establishment of the Mobile Logistic Support Group (MLSG) concept.

The MLSG concept parallels the support concept used by the aviation community in that the weapons system is primarily manned by operators and most maintenance is to be performed during the brief time when the system is not operational. The use of this maintenance concept requires special consideration during design. For example, levels of reliability and maintainability are needed which minimize the need for preventive and corrective maintenance actions underway. Additionally, the ship was designed with significant built-in test equipment to facilitate fault detection, isolation and repair. This equipment, in conjunction with the standard hand tools carried aboard, could be used to effect repairs while underway. Onboard spares are limited in range and depth and mostly include only fuses, light bulbs and critical modules [3].

The ship was logistically designed to operate at sea for short periods of time up to five days maximum.

During this time period, some limited daily preventive maintenance would have to be performed and emergency corrective maintenance may be required. All other maintenance is deferred to the MLSG. It was decided early in the conceptual phase that the operators of the ship must be skilled enough to perform these underway maintenance tasks. The manning concept then became one of utilizing few numbers of highly skilled individuals for the PHM who could operate the equipment and maintain it if necessary.

Knowledge regarding required personnel quantities and skill levels was gained through the fleet use of previous hydrofoil craft built for the U. S. Navy. This experience, combined with the expected weapons configuration of the PHM, made it possible to estimate the berthing and living requirements for the ship. Once the total number of personnel was known the ship was designed around that quantity.

The final ship's design limited crew size to five officers and nineteen enlisted men. Appendix A lists the manpower requirements and gives the procedure used to determine them. Appendix A's inclusion is intended to exemplify the degree of detail that entered the logistics and design planning phases. It also establishes the need for filling operational billets with qualified crew members.

Training of the PHM crew was another consideration that entered the design trade-off process. The

reduced operational and maintenance manning concepts and the sophistication and uniqueness of the hardware systems created an extraordinary training requirement for the crew members. Furthermore, this training had to be received prior to reporting for duty aboard ship since the lack of extra berthing space would limit the opportunity for on-the-job training while underway. The problems of training such crews will be discussed in a later chapter.

Although the built-in test equipment would reduce the maintenance training requirements to some extent, the crew would still have to be trained to correct any critical equipment breakdown that might occur during the five-day mission. These training requirements were forecasted and planned for in the Navy Training Plan (NTP) [4] for PHM. Appendix B discusses the training concept in more detail.

C. PROTOTYPE PRODUCTION AND EVALUATION

The optimistic results of the feasibility studies performed by Boeing and NATO Project Group Six and the earlier U. S. Navy Hydrofoil supporting technology are reported by Duff [5]. A favorable DSARC II decision resulted and the Navy awarded the U. S. lead ship design and construction contract to Boeing in February 1973. Construction commenced in April 1973. The ship, USS PEGASUS (PHM-1), was launched in November 1974, six weeks behind schedule.

The launching was followed by an extensive test and evaluation of the platform and combat systems culminated

by a one-month independent Operational Evaluation (OPEVAL) by Commander, Operational Test and Evaluation Force (COMOPTEVFOR) in May 1976. Complete results of this test program are reported by Duff, Schmidt and Terry [6].

An eight-month major overhaul commenced in September 1976 to correct OPEVAL deficiencies. According to Shrader and Duff [1] the overhaul period was used "to strengthen the foils and struts in areas where cracking has occurred, and the main propulsor gearbox was refurbished with stiffer pinion shafting, higher quality gears and improved load carrying gear configuration. Also, the aluminum propulsor inlet duct was modified slightly to extend life, and a number of combat systems improvements were incorporated, including a combined radar video and navigation chart display (TANCAV) for both the Combat Information Center and the Pilot House and an improved seating and weapons control capability for the Tactical Action Officer (TAO) station".

These and other minor deficiencies were corrected by April 1977 and Navy Acceptance Trials (AT) were conducted in June 1977 by the Board of Inspection and Survey (INSURV). The president of the INSURV Board cited PEGASUS as having one of the finest trials "in the memory of the Board" [1]. PEGASUS was delivered to the Navy in June and commissioned in July 1977.

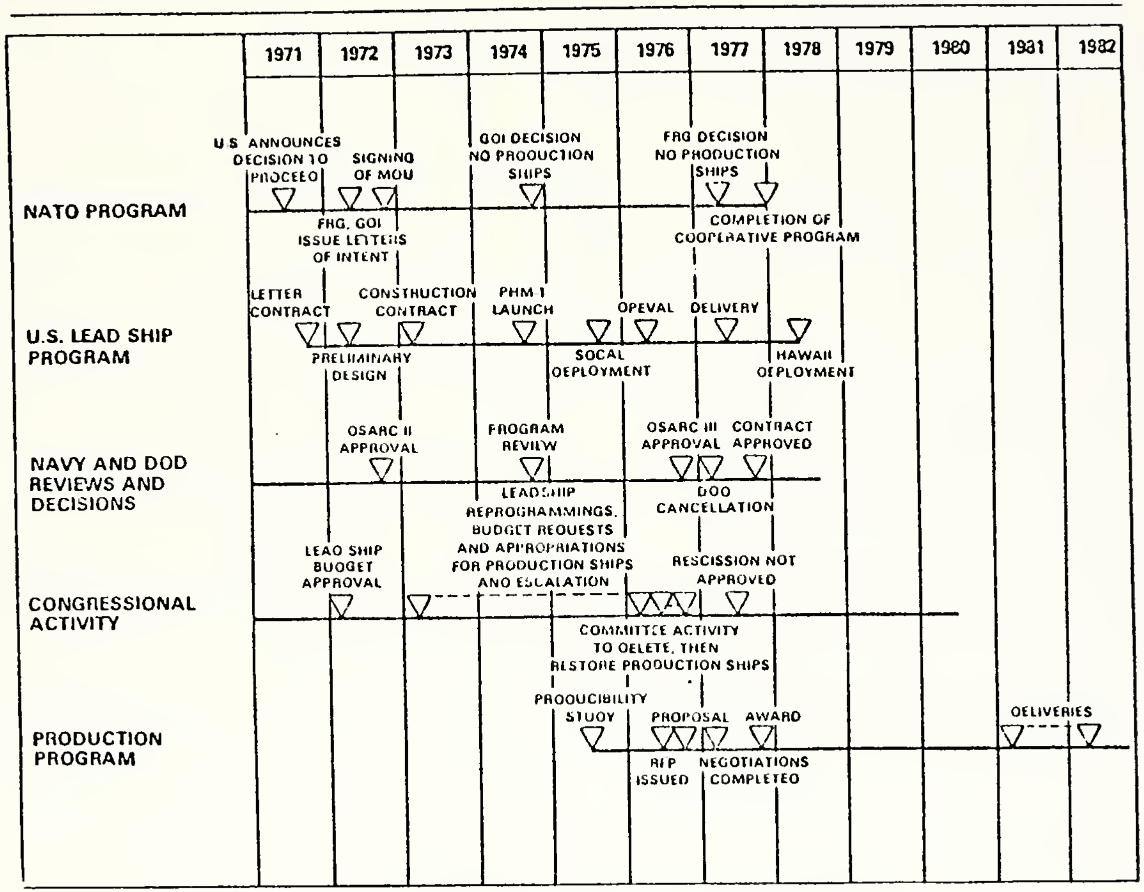
D. PRODUCTION DECISIONS

Understanding the historical account of the PHM acquisition program process is facilitated by examining Table 4, courtesy of Shrader and Duff [1]. Briefly, FY 1975 and FY 1976 funds were appropriated for five production ships and a fixed price incentive production contract was awarded to Boeing in October 1977. Production is underway at this time, but a flurry of political activity between 1974 and commencement of production, at times, made the fate of the PHM uncertain. The following sub-paragraphs itemize some of the decisions. The rationale for these decisions will be discussed in more detail in the "Analysis" chapter which follows.

1. Production Approved for Five PHMs

1974 was a turbulent year for the PHM program. Navy in-house bickering over weapons suites, technological difficulties experienced by the Boeing Company during construction of the prototype and schedule delays caused a significant upward trend in the estimated cost per ship. A PHM Project Office spokesman stated that cost escalation caused the Congress in 1974 to approve funds for only five of the proposed 28 production ships. Only strong DOD and Navy appeal action saved the program from being deleted altogether. In addition, the Government of Italy decided to withdraw from the program and to pursue construction of smaller less expensive hydrofoils independent of the NATO effort.

TABLE 4



Major Events and Activities of NATO PHM Program.

2. Request for Proposal

In June of 1976, the "Request for Proposal" was issued and the Boeing proposal was received in October 1976. The successful Acceptance Trials of the PEGASUS and enthusiastic comments from fleet operational commanders who had observed its use caused a favorable DSARC III decision by the end of 1976 despite issues raised by DOD systems analysts to the effect that the ship was not sufficiently cost effective to justify its procurement. In January 1977 the Deputy Secretary of Defense advised the Secretary of the Navy (SECNAV) that production of PHMs could proceed.

3. Recision Proposal

When the Administration changed on 20 January 1977, defense priorities were reevaluated in anticipation of a balanced federal budget by 1981. Based on its own studies and the expectation of budget cuts, the Navy now felt that the PHM was not sufficiently cost effective when compared to other spending priorities [7]. The rationale behind this change will be discussed in the "Analysis" chapter. The Navy withdrew the $43M planned for conversion of a mothballed LST into a hydrofoil support ship from the FY 1978 budget and, instead, requested funds to deactivate the two operational platforms, the PCH-1 and AGEH-1, for hydrofoil research and development.

Defense Secretary Brown announced by memorandum in April that the United States was planning to terminate the PHM program. Since Boeing had not yet begun production on the five remaining PHMs, President Carter submitted a proposal to rescind the FY 75 and FY 76 funds which had been appropriated for that purpose. (Passage of a recision bill requires favorable action by both Houses of Congress within 45 days of submittal.) [8].

Testimony was heard by the Defense Subcommittee of the House Appropriations Committee in July 1977 and, despite unanimous DOD support in favor of recision, Congress favored the program's continuation and the recision bill did not pass. The Navy was obligated to proceed with the five production ships and Boeing commenced construction in October 1977. Delivery will occur in 1981 and 1982.

Congress did, however, accept the Navy's suggestion to cut budget support for a logistics platform for the MLSG. The PHM program office advises that an alternate platform consisting of 50 portable vans was recently proposed by the Navy and is included in POM 81.

4. NATO Program Ends

In May 1977 the Federal Republic of Germany withdrew from the PHM program to build less costly non-hydrofoil missile patrol boats [7]. This event brought

an end to major NATO involvement in the PHM program. All that remains is the procurement of the foreign equipments for the U. S. variant.

III. ANALYSIS

The most significant observation about the PHM's history that would cause one to question the success of the PHM program is the drastic reduction in scope that has occurred since the program's inception. To summarize, PHM began as a 60 ship NATO program, half of which were for use by the United States. Support for the program gradually deteriorated on grounds of reduced cost effectiveness, beginning with the Congress in 1974 and ending with the Navy and the Federal Republic of Germany in 1977. It is only because of Congressional insistence that five ships are currently being built.

This chapter deals with the rationale which caused the PHM to lose its attractiveness in comparison with other programs, and the problems the current program manager faces as a result of the cutback.

A. COST EFFECTIVENESS

Competition for limited federal funds is evident throughout the government. The Department of Defense competes with other governmental agencies and the individual services compete for their shares. Within a

service, individual programs such as the PHM compete with other programs. Since there are not enough dollar resources to fund each program a service believes it needs in performance of its mission, measures of effectiveness are necessary to evaluate and prioritize them. Highest priority funding consideration is logically given to the programs which provide the most national defense per dollar expended.

Cost effectiveness provides such a measure and is used to rank programs. It considers the mission category, e.g., anti-surface ship warfare, anti-air warfare or anti-submarine warfare, and, through simulated battle techniques, computes the cost of each enemy ship, submarine or aircraft killed [7]. This figure can be used to compare the relative merits of programs in similar mission roles.

1. Cost

The technology base which indicated the PHM to be a low-risk venture was apparently not as solid as was previously supposed. In 1974, cost escalation on the order of two times the original estimates raised the price from $20.5M to $41M per copy (both figures in 1974 dollars) and was cited as the reason for all the anti-PHM decisions which followed [7]. The consequent reduction in cost effectiveness caused the first cutback from 28 to five production ships, the withdrawal of NATO participants and

lessened interest by the U. S. Navy. In defense of the program, cost growth should be placed in perspective as follows: (All figures in 1974 dollars.) Original estimates of unit ship cost for a production run of 28 ships was approximately $20.5M. Program growth and escalation moved the unit price for 28 ships upwards to $28.9M corresponding to a cost growth factor of 1.4. Cutting the program back to five ships made the unit price $41.1M and accounts for the majority of the cost growth factor of two. Cost growth of 1.4, although still not desirable, is not unusual in shipbuilding programs. This figure compares favorably with the cost growth factor of 1.5 experienced by the highly successful FFG-7 program [7].

2. Mission

The Federal Republic of Germany was the first to express a need for improved anti-surface ship capability which led to the NATO mission requirement. They needed a patrol craft to operate in the Baltic Sea to prevent amphibious landings by the Warsaw Pact forces in the area of the Baltic Sea approaches associated with attempts to secure the entrance and exit to the sea. For their purpose, the ship's mission was specific and single purpose. Long-range capability of the ship was not a critical factor because its operation was tied to a specific geographic location and integrated with German

land-based naval aviation. The PHM was especially suited for this mission because it served as a stable platform which enabled the effective use of the surface to surface weapons during rough seas [7].

Even though operation of the U. S. variant of the PHM would not be restricted to a specific geographical area, it was felt that its mission would approximate the FRG mission, i.e., patrol coastal and choke point areas similar to the Baltic Sea approaches [7]. Since it only had anti-surface ship capability, its use would be restricted to relatively benign areas where enemy aircraft and submarines would not pose a threat. It would therefore be used in a supportive role to free up larger multi-mission combatants for more hostile environments by patrolling those areas where only a surface threat was expected. It was felt that procurement of a single mission ship was justified if it could be produced at a low cost [7].

3. The Harpoon Missile

The NATO perceived threat of Warsaw Pact combatants has not gone away or changed. The technology for challenging the threat, however, has changed. Prior to the development of the Harpoon missile, guns mounted aboard ships served as their primary anti-surface ship weapons system. However, high seas states interfere with the use of guns. Therefore, the submerged foil hydrofoil was valued since it could provide the most stable platform to use the guns effectively.

The Harpoon missile is a recent innovation in anti-surface ship warfare. It is an anti-ship cruise missile with a range of about 60 miles [7]. Most significantly, its use does not require a stable platform. For this reason, the Germans decided to buy Harpoon-equipped non-hydrofoil patrol boats large enough to maneuver in rough seas. They felt that this vessel could accomplish their mission almost as well as the PHM, but at half the procurement cost [7].

The U. S. Navy is currently equipping all destroyers, frigates, cruisers, land-based P-3 ASW patrol aircraft and the carrier-based A-6 aircraft with Harpoon missiles. According to Admiral Holloway [7], this action will give the U. S. Navy adequate anti-surface ship capability without building more PHMs.

In the area of anti-surface ship capability, cost effectiveness studies comparing the PHM with the P-3 and FFG-7 showed the P-3 to be slightly more cost effective than the PHM and the FFG-7 was slightly less. Even though the indices of cost effectiveness were very close to one another it must be remembered that the P-3 has, in addition, ASW capability and the FFG-7 is AAW and ASW capable. Therefore, the Navy concluded that given limited funds, procurement of multi-mission systems were preferred over the PHM [7].

The preceding mission and cost data was presented and discussed during the recision hearings in July 1977

[7]. DOD and the Navy favored the recision of the FY 75 and FY 76 funds appropriated for production of five more PHMs in spite of favorable comments by Navy spokesmen regarding the fact that the hardware had met all of its operational expectations. Furthermore, when questioned about the possibility of adding an additional capability such as ASW, Navy spokesmen testified that such a change would not be feasible with the present fixed design.

The Navy was not as concerned with the funds already appropriated as it was with the future outlays expected by operation of the PHM squadron which would run from $20M to $50M per year. Looking ahead to the 1980-81 timeframe which the President set for balancing the budget, the funds used to operate PHM would displace something else that the Navy would rather have.

B. POLITICAL INFLUENCES

The strongest opponent of the President's recision proposal was the Representative from Seattle (and Boeing's) Congressional district. In his opening remarks at the hearing [7], he reminded the Subcommittee of the growing imbalance of naval power between the United States and Soviet Russia and the need to protect our high value carrier task groups. He felt that PHMs were a viable means of freeing up these task groups in the Mediterranean and northern NATO flanks because their cost is about one-third the cost of the next least expensive combatant, the FFG-7, and their small

size, speed and maneuverability make them less vulnerable to torpedo and cruise missile attack. With the Navy growing progressively smaller, he questioned the Navy's judgment in terminating a program of highly capable ships that has already been paid for. He also reminded the Subcommittee that as late as March 1977, the Secretary of the Navy, the Chief of Naval Operations and the surface mission sponsor (OP-03) had strongly advocated continuance of the program.

After hearing all testimony, the Subcommittee voted against the recision and the proposal did not go before the House. They (the Subcommittee) felt that the PHM squadron was a seapower concept which differed sufficiently from the Navy's traditional strategy of fewer, large multimission ships to warrant evaluation. As a result of this action, the Navy and DOD were forced to accept a program which they had testified against.

Interestingly, the roles of the Congress and the Navy in presenting pro and con arguments at the recision hearings were completely reversed from the funding hearings in 1974. This reversal is probably due to a changing environment which manifests itself in the goals of decision makers. A new President with new fiscal policies could have caused the Navy to anticipate budget reductions and therefore, reevaluate its priorities. A greater awareness of the growing imbalance of naval capability between the U. S. and the U. S. S. R. could be a factor which partially reversed the Congressional position on PHM. In any event, the

point here is that a changing political environment appears to have greatly affected the outcome of the program.

C. CURRENT PHM MANAGEMENT PROBLEMS

Having analyzed the rationale behind the program's reduction in scope, the unwillingness of the Navy to accept the program and the Congressional reasons for its continuation, the logical next step is to analyze the effects of these events on the current management of the program.

Briefly, the current status of the program is as follows: What was once a 60 ship NATO program now consists of only six ships. The number of U. S. operational personnel involved, including ship's crews, squadron and MLSG personnel, has been correspondingly reduced from 1000 to 200. The NATO interoperability requirement that was responsible for the metric design and unique foreign equipments no longer exists. The MLSG platform has been changed from an afloat tender to a complex of mobile van containers and has resulted in the degradation of the PHM's operational flexibility in possible mission scenarios [7].

The most significant problem the current program manager faces today is implementation of the logistics plans that were formulated when Navy support for the program was much stronger. Albeit the scope of the program has decreased, the ship itself has not changed, and the same logistic support requirements still exist.

It was decided at the time the design trade-offs were being made concerning manning and training that it was more

feasible to rely on priority detailing and training than it would be to change the ship design to carry more crew members. It was also recognized that implementation of these plans would require special consideration by the Bureau of Naval Personnel (BUPERS) and the Chief of Naval Education and Training (CNET). Continued cooperation of these commands was justifiably assumed given the NATO involvement, Navy-wide enthusiasm and the large number of personnel involved when this assumption was made. Now that only six ships remain, and the NATO political aspect has disappeared, the enthusiasm to provide a specialized logistic environment for the PHM has disappeared as well.

Table B1 indicates the prerequisite training courses originally requested and those actually received. The reduction of training at established Navy schools was largely aimed at courses designed to enhance the maintenance capability of equipment operators. BUPERS justified deletion of these training courses based on their literal interpretation of the PHM maintenance concept. Theoretically, this is a valid argument because decreased maintenance training is the benefit of a maintenance practice which utilizes replacement modules and standard hand tools for equipment repair. Detailed technical expertise at the equipment part level is not required when such modules are available.

Implementation of the maintenance and training concepts has not been a problem with regard to the equipment

designed especially for the PHM. Government furnished equipment (GFE) on the PHM, however, does present a problem because these equipments were designed for use aboard ships with traditional maintenance practices. Replacement modules are not currently available and detailed technical expertise is required to repair these equipments at the part level.

The Fleet Support Improvement Program (PMS 306) has been responsible for developing replacement modules for GFE aboard PHM but, according to the PHM program office, has not shown significant progress to date because its efforts have been dedicated to the GFE associated with larger programs such as the FFG-7. To compensate for this lack of progress, the PHM program manager requested additional maintenance training in the Navy Training Plan for PHM.

Had the PHM maintained its position as a major program, then perhaps PMS 306 would have shown earlier results with GFE modularization or BUPERS would have granted the additional training.

Table B 2 lists the associated training equipments and indicates almost all are not supported by the OP-39 sponsor. The argument to justify this position is that such a purchase of training aids would not be cost effective due to the small number of personnel who would benefit from their use [9].

These examples indicate a reluctance on the part of the Navy to commit resources and attention to other than the

most major and visible programs. While this strategy is probably best in view of scarce resources, it is bound to take its toll on PHM effectiveness. This causes a problem for the program manager because he is responsible for demonstrating the full potential of a PHM squadron consistent with Congressional desires, but he is not receiving the total support or resources to accomplish this objective.

IV. LESSONS LEARNED

There are many unique aspects of the PHM program which distinguish it from traditional ship acquisition programs. The hardware itself and its capabilities, the manning and maintenance policies and the NATO involvement all required innovative management approaches to integrate them into a single system. The problems experienced by the program, however, can be categorized into areas which can affect any acquisition project no matter how unique it is, how effectively it is managed or how well the system performs. This chapter focuses on some of the specific circumstances which seriously affected the outcome of the program and categorizes them into general system acquisition problems which have the potential to affect any program, regardless of the program manager's efforts.

A. COST

The PHM was first estimated to cost $20M per copy (1974 dollars) for 28 ships. The target price in the fixed

price incentive production contract for five ships is $63M each (1978 dollars). Discounting for inflation and reduction in size of the production run, there was actual cost growth of approximately 1.4 times the original estimate. Admiral Holloway [7] indicated that such cost growth is usual in shipbuilding programs.

Fox [10] confirms that cost overruns are a fact of life and generally occur either because original estimates were too low, or because the program was not adequately controlled to prevent inefficiencies. For obvious reasons, however, a program manager who finds himself in an overrun situation will most likely maintain that the original estimate was too low.

Fox also points out that simply increasing the original estimate would not solve the problem since contractors' internal budgets are determined by the amount of funds available. Higher estimates would only mean higher planned costs. Competition causes contractors to use only the most optimistic cost estimates. Likewise, the program manager must use the most optimistic estimate in order to remain competitive with other programs for funding.

Therefore, in programs where costing data is not known with certainty, program managers and contractors alike stand to gain more from being cost optimistic than they stand to lose if cost overruns occur. The rewards and punishments in the present acquisition process make cost overruns inevitable [10].

B. CHANGE

The time that will have elapsed between the conception of the PHM and the final production is approximately 12 years. This lengthy time period is also not unusual for shipbuilding programs. Time itself is not necessarily a problem, but the longer the process takes, the longer the program is exposed to the probability of changes in technology and decision makers and their attitudes.

The PHM and the Harpoon missile were developed during the same approximate time period. The Harpoon was considered by the PHM project office to be a system that would enhance the effectiveness of the PHM rather than be a threat to its existence. From a national defense standpoint, advancing technology can certainly not be considered a problem, but to those loyal to the PHM, the advent of the Harpoon missile combined with cost escalation made the PHM appear less attractive when compared to alternate methods of anti-surface ship warfare. Had cost overruns not occurred, or had technology not produced the Harpoon missile, the PHM would have maintained its position as a major NATO program. The point here is that a program manager cannot readily assess the impact of advancing technology in another program on his own program, nor would it make a difference if he could. His activities are confined to his own area of responsibility.

Decision makers change over time either by election, promotion, retirement, et cetera. New decision makers bring new attitudes and beliefs regarding the "best national interests". Former CNO Admiral Zumwalt was a strong proponent of the PHM program during his tour as CNO [11]. He recognized the PHM as a new level of naval weapons capability which should be actively pursued. His opinion was based on recognition of reduced manpower and fiscal resources within the Navy to combat the increasing Soviet threat. The PHM offered a more versatile and less expensive weapons system than the Navy has ever known before. Zumwalt therefore believed that it made good sense to build a portion of our naval capability around PHMs to relieve the vulnerability of our high value targets and increase the total number of ships. He also supported the concept of an afloat MLSG to provide maximum mobility for the PHM squadron.

Admiral Holloway, who relieved Admiral Zumwalt as CNO, agreed that the PHM was a good naval asset to have, however, he felt that the Navy's limited resources could be better spent on other programs. He testified accordingly in a House subcommittee hearing when the President attempted to rescind the funds obligated for construction of PHMs [7]. Admiral Holloway's views were consistent with those of the newly appointed Secretary of Defense Brown and Secretary of the Navy Claytor who were establishing

defense priorities in accordance with newly elected President Carter's campaign promise to balance the federal budget. No attempt will be made here to justify or argue the decision to delete the PHM from the budget. The point of this observation is that different personalities and objectives of major policy makers greatly influenced the eventual outcome of the program, in spite of the program manager's efforts to make his program a success.

C. CONTROL

One major problem of the acquisition process that affected the PHM is the apparent lack of a central source of control over commitment, continuity or responsibility for the effective management of the program. Theoretically, all program decisions should be consistent with the "best national interests". Realistically, however, this is an unachievable endeavor since the term takes on different meanings depending on the political point of view of the decision maker and the time period involved. Given a dynamic environment where the concept of the "best national interests" changes continuously, there is not nor can there be any central control or responsibility to assure continuity of the decision process.

There are numerous examples of discontinuous control throughout the PHM program. The NATO PHM Program Manager had no control over the participating countries. There was no commitment of funds and no way to enforce continued

participation to keep the program on a large scale to minimize the unit cost. On a national level, a similar event occurred by a change in Presidents and Secretaries of Defense. A President is not obligated to continue the policies and programs of his predecessor.

With this type of discontinuity evident at the highest levels, it is not difficult to understand how a commitment might be agreed upon by the members of an early DSARC (Defense Systems Acquisition Review Council) to rely heavily on training at Navy Schools later in the PHM's life cycle. Not only can the DSARC members' objectives change with the President's, but also the members of the committees are likely to change before it becomes time to implement the earlier decision. The PHM program manager position itself turned over three times prior to the commencement of construction on the five production ships.

Another example of discontinuous control and differing prospectives on the "best interests of national defense" is the power struggle between the Legislative and Executive Branches of Government as it applies to the eventual outcome of the PHM program. The reason the ships are being built is because of Congressional desire to examine a PHM squadron's potential as an alternate sea power strategy. The Executive Branch was desirous of deleting the program. In order to objectively evaluate the PHM's potential requires the outlay of a few more dollars to provide the proper training support environment. To not provide the

training support as planned makes it impossible for the ship to perform as it was designed. This approach may have saved some dollars in training, but the true benefit of the sunk cost of ship construction will never be known. A cooperative effort by the Executive and Legislative Branches would have either caused continuation of the program with full support or deletion of the program altogether (thereby saving hundreds of millions of dollars).

Fox [10] discusses additional factors in the systems acquisition process which have the potential to affect the outcome of a program and are beyond the span of control of the program manager.

V. SUMMARY

The PHM is a defense application of the latest hydrofoil technology. It is a unique ship class not only because of its appearance and operational capabilities, but also because of the non-traditional considerations that entered the design trade-off process. The reduced manning and maintenance concepts and the original NATO interoperability concept all presented non-traditional challenges to the management of the program.

In one respect, the program can be considered a complete success. The early detailed planning that produced the final design paid off because the ship, as evidenced by the testing of the prototype, is capable of performing

the mission tasks which precipitated its development. This success can be rightfully attributed to the program manager because the operational capability of the ship is the result of efforts under his direct control.

In another respect, however, the program was not completely successful because it did not maintain its position as a major program. The factors that caused the reduction in the program's scope such as cost escalation, advancing technology (the Harpoon missile) and varied interpretations of the "best national interests" by decision makers external to the program office, were factors over which the program manager could not exercise control.

These factors point to the unavoidable characteristic of the systems acquisition process which is the lack of a central controlling entity to provide for a consistent and stabilized basis on which to make program decisions. This characteristic gives the systems acquisition process strength in that it forces programs to adjust to a changing environment. However, the same characteristic has a weakness which manifests itself as additional expense or decreased effectiveness.

APPENDIX A

PHM MANPOWER REQUIREMENTS

The discussion which follows is the procedure used for the preparation of the PSMD for the PHM-1 class ship [12]. It serves as the justification for the manning level currently used aboard PHM. To summarize, the document is prepared in the following steps:

1. Projected Operational Environment (POE) is reviewed.
2. Operational billets are identified.
3. Total weekly manhours required to operate and maintain the ship are computed.
4. Manhours are allocated to billets subject to constraints.

A. PROJECTED OPERATIONAL ENVIRONMENT (POE)

The projected operational environment establishes the most demanding operational condition for which a ship must be manned. The POE for the PHM class is "at sea in wartime". This presupposes enough personnel to perform all offensive and defensive functions while in Readiness Condition I (all hands - General Quarters) and maintain Readiness condition III (port and starboard - two section watch) at sea for periods of five days followed by two days of upkeep during which time the ship's crew will be on liberty and the MLSG personnel will perform necessary maintenance.

B. WATCHSTANDING AND OPERATIONAL WORKLOAD REQUIREMENTS

Predictions for the number of personnel required to operate the ship in its projected operational environment (Readiness Conditions I and III) were based on the experience gained by the operation of previous hydrofoil craft and the known weapons configuration of the PHM.

As indicated by Table A1, 17 persons are required for Condition I and 15 for Condition III (an officer assumes one of the watchstations in the starboard section). These figures became the basis for the establishment of 17 billets (15 watchstanders and 2 non-watchstanders). Rates and ratings for each billet were determined by a combination of experience and application of the operational functions and task statements contained in the Navy Enlisted Occupational Standards [13]. The operational billets and their personnel requirements are summarized in Table A2.

Although the ship must have the capability of achieving Condition I readiness, the operational hours are based on Readiness Condition III. The hours allocated to operational manning is 60 hours per week per watchstander (5 days /week x 12 hours /day /watchstander).

C. PREVENTIVE AND CORRECTIVE MAINTENANCE (PM & CM) WORKLOAD

Organizational level preventive maintenance assigned to the PHM crew is limited to daily preventive maintenance tasks which cannot be rescheduled to the in-port periods.

TABLE A1

CONDITION WATCH ASSIGNMENTS

Station Title	CONDITION I		(Condition III) PORT		STARBOARD	
	RATE	BILLET#	RATE	BILLET#	RATE	BILLET#
COMMANDING OFFICER	LCDR	0-101				
SHIP CONTROL - PILOT HOUSE/BRIDGE						
A1. OOD	LTJG	0-104	QMC	OP-101	LTJG	0-104
A2. SHIP CONTROL CONSOLE OPR. (HELM.)	BM2	OP-201	BM2	OP-201	GMG1	W-101
A3. LOOKOUT/PHONE TALKER	ET2	W-104				
INFORMATION CONTROL - CIC						
B1. TACTICAL ACTION OFFICER (TAO)	LT	0-102	LTJG	0-103	LT	0-102
B2. NAVIGATOR	QMC	OP-101	OS2	OP-103	OS1	OP-102
B3. COMMUNICATOR	RM2	OP-105		*		*
B4. SURFACE DETECTION TRACKER	OS2	OP-103	ET2	W-104	IC2	E-105
B5. DRT PLOTTER	OS1	OP-102				
B6. VERTICAL PLOTTER	MS2	OP-202				
B7. ESM OPERATOR	EW3	OP-104	EW3	OP-104	ICFN	E-106
WEAPONS CONTROL - CIC/HANDLING ROOM						
C1. WEAPONS CONTROL OFFICER (WCO)	LTJG	0-103				
C2. SURFACE TARGET OPERATOR	FTG2	W-103				
C3. AIR TARGET OPERATOR	FTG1	W-102	FTG1	W-102	FTG2	W-103
C4. GUN CAPTAIN/LOADER	GMG1	W-101				
C5. AMMUNITION HANDLER	ICFN	E-106				
ENGINEERING CONTROL - E.O.S. (ENGINEERING OPERATING STATION)						
D1. ENGINEER OPERATOR	ENC	E-101	EN1	E-102	ENC	E-101
D2. ASST. ENGINEER OPERATOR	EM2	E-104	EM2	E-104	EN3	E-103
DAMAGE CONTROL - D.C. LOCKER						
E1. REPAIR PARTY LEADER	EN1	E-102				
E2. REPAIR PARTY	IC2	E-105				
E3. REPAIR PARTY	EN3	E-103				

*The RM2 is on-call.

TABLE A2

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

Operations Department

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
OP-101	QM	C (E-7)	OOD (P)	o Stands OOD watches under guidance of senior watch officer (OPNAVINST 3120.32). o Assists navigator and maintains charts, publications, navigation instruments, and keeps correct navigation time. o Renders "Honors and Ceremonies". o Sends and receives visual messages.
OP-102	OS	1 (E-6)	Navigator (S)	o Coordinates efforts to restore CIC operations under battle and emergency conditions. o CIC Watch Supervisor underway. o Assists Tactical Action Officer. o Performs navigational duties by traditional and electronic methods. o Maintains plots. o Solves maneuvering board problems for change of station and emergency procedures. o Provides cryptographic services.
OP-103	OS	2 (E-5)	Navigator (P)	o Performs navigational duties. o Performs duties of navigation plotter during piloting, anchoring, NGFS. o Solves maneuvering board problems. o Provides cryptographic services.
OP-104	EW	3 (E-4)	ESM (P)	o Operates ESM, ECM, and CHAFF (RBOC) equipments. o Performs organizational level at-sea maintenance on ESM and RBOC equipments. o Maintains records on electromagnetic emissions.

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

Operations Department (continued)

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
OP-105	RM	2 (E-5)	Non-Watchstander	o On call for all radio and teletype communications. o Performs organizational level at-sea maintenance on telecommunication equipment. o Advises command on telecommunication capabilities. o Performs routine clerical duties in telecommunications center. o Corrects and maintains classified publications.
OP-201	BM	2 (E-5)	Ship Control Console Operator-Helmsman (P)	o Controls remote throttle,helm; operates automatic control system in hullborne and foilborne modes. o Supervises loading, discharging, stowing of cargo. o Supervises rigging for fueling at sea, high line, and preparation for mooring or anchoring. o Supervises all activities relating to marlinspike, deck and boat seamanship. o Responsible for organizational level at-sea upkeep of deck gear and equipment.
OP-202	MS	2 (E-5)	Non-watchstander	o Operate and manage shipboard mess to include: -Planning daily menues -Preparing and serving meals -Requisitioning and accounting for stores and materials -Preparing daily subsistence & other reports -Setting and clearing mess tables -Performing daily organizational level facility maintenance -Maintaining sanitary conditions -Supervising mess line during serving of meals

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

WEAPONS DEPARTMENT

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
W-101	GMG	1 (E-6)	Ship Control Console Operator Helmsman (S)	o Supervises loading, operation, and performs organizational level at-sea maintenance of MK 75 Gun Mount. o Supervises crews in transferring, handling, and stowage of ordnance. o Performs tests & inspections of magazines, hydraulic systems, and power circuits. o Instructs crew in gun mount operation, small arms & safety. o Prepares logistic reports and maintains records. o Controls remote throttle, helm; operates automatic control system in hullborne and foilborne modes.
W-102	FTG	1 (E-6)	Air Target Operator (P)	o Operates weapons control console; solves fire control problems. o Assists tactical action officer in high speed navigation collision avoidance. o Operates Harpoon missile system & IFF. o Operates, tests, and performs organizational level at-sea maintenance on MK 92 MOD 1 FCS. o Analyze fire control system failures and direct emergency mission-critical corrective maintenance
W-103	FTG	2 (E-5)	Air Target Operator (S)	o Operates weapons control console; solves fire control problems. o Assists tactical action officer in high speed navigation collision avoidances. o Operates Harpoon missile & IFF systems o Operates, tests, and performs organizational level at-sea maintenance on MK 92 MOD 1 Fire Control System. o Localizes equipment casualties to systems, subsystems, circuits.

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

Weapons Department (continued)

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
W-104	ET	2 (E-5)	Surface Detection Tracker (P)	o Performs tests and organizational level at-sea maintenance on communications, electronic, cryptographic, detection, and tracking, recognition and identification, and aids to navigation equipments. o Performs organizational level at-sea maintenance on ship's automatic control system. o Performs emergency mission-critical corrective maintenance. o Operates related equipment such as radar, IFF.

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

ENGINEERING DEPARTMENT

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
E-101	EN	C (E-7)	Engine Operating Station (EOS-S)	o Serves as engineering officer of the watch. o Monitors mechanical and electrical parameter displays at engineering operating station (EOS) console. o Supervises operation of main propulsion plants: Gas Turbine and Diesel. o Supervises operation of auxiliary electrical and mechanical equipments. o Maintains engineering log and records. o Supervises operation of high pressure hydraulics equipment unique to PHM system. o Monitors damage control panels. o Supervises accomplishment of emergency mission - critical corrective maintenance.
E-102	EN	1 (E-6)	Engine Operating Station (EOS-P)	o Serves as engineering officer of the watch. o Monitors EOS Console. o Operates Main Propulsion Plants, Gas Turbine and Diesel. o Supervises operation of electrical and mechanical auxiliary equipments. o Performs organizational level at-sea emergency mission - critical repairs. o Maintains Engineering log and records. o Supervises ship's damage control party.

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

Engineering Department (continued)

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
E-103	EN	3 (E-4)	Assistant Engine Operating Station (EOS-S)	o Assists Engineering Officer of Watch at EOS console. o Makes periodic checks of engineering spaces to detect hazards or malfunctioning equipment. o Operates auxiliary equipments not controlled at console such as air conditioning, distiller, pumps. o Performs organizational level at-sea maintenance such as checking oil levles, inspections and replacing filters and strainers, repairing hydraulic system leaks. o Operates firefighting equipment; member damage control party. o Maintains operating records.
E-104	EM	2 (E-5)	Assistant Engine Operating Station (EOS-P)	o Assists Engineering Officer of Watch at EOS console. o Makes periodic checks of engineering spaces to detect hazards or malfunctioning equipment. o Operates auxiliary equipments. o Detects grounds, open & short circuits in lighting & power circuits and motors. o Estimates electrical casualties and performs emergency mission-critical corrective maintenance. o Performs organizational level at-sea maintenance on ship's electrical circuits, galley equipment, ship's service power unit, audio-visual equipment, and equipment control circuits. o Maintains operating records.

TABLE A2 (CONT.)

ENLISTED QUALITATIVE MANNING REQUIREMENTS JUSTIFICATION

Engineering Department (continued)

BILLET #	RATING	RATE	CONDITION III (P) WATCH STATION (S)	BILLET REQUIREMENTS (Includes Operational Functions and Task Statements derived from NAVPERS 18068D - Navy Enlisted Occupational Standards)
E-105	IC	2 (E-5)	Surface Detection Tracker (S)	o Operates gyrocompass, tape recorders, and phone announcing systems. o Performs organizational level at-sea maintenance on: -Automatic propulsion control system (for LM-2500 Gas Turbine) -Plotters & Dead Reckoning Equipment -IC and ACO Switchboards -Gyrocompass -Motors & Controllers o Operates related equipments such as radar and IFF.
E-106	IC	FN (E-3)	ESM (S)	o Operates ESM, PHONE and general announcing systems. o Assists lead IC Electrician in organizational level at-sea maintenance. o Operates and maintains ship's entertainment system and closed circuit TV. o Rigs Phones.

All other PM is accomplished by the MLSG during the two-day upkeep period. A planned maintenance system automated list tailored to the prototype, USS PEGASUS (PHM-1), was used to obtain a listing of shipboard equipments. Most equipments have established Navy standards which itemize the maintenance task, man-hours to accomplish, skill level and frequency of the maintenance action. By use of these figures, the weekly man-hour requirement for preventive maintenance was determined by totaling the daily task man-hour requirements and multiplying by five days per week. The daily preventive maintenance for the remaining two days is accomplished by the MLSG. The total preventive maintenance man-hours assigned to the ship's crew is 23.5 plus an additional standard of 30% of the preventive maintenance man-hour requirements for each billet for "make ready - put away" time.

Corrective maintenance is estimated as a function of preventive maintenance hours. In order to estimate corrective maintenance it is necessary to separate the preventive maintenance into categories as follows: 1.5 weekly hours for electronics technician (ET) type work and 22 hours for all other preventive maintenance work. As specified by OPNAV instructions [14], the standard ratio of PM to CM for estimation is one hour of PM to one hour of CM for ET-type work and two hours of PM to one hour of CM for all other work. Maintenance weekly man-hours are summarized in Table A3.

TABLE A3

PREVENTIVE AND CORRECTIVE MAINTENANCE HOURS

	ELECTRONICS (ET TYPE)	ALL OTHER	TOTAL
PREVENTIVE MAINTENANCE	1.5	22.0	23.5
CORRECTIVE MAINTENANCE	1.5	11.0	12.5
PRODUCTIVE ALLOWANCE (30% OF PM)	.45	6.6	7.05

D. FACILITY MAINTENANCE (FM)

Facility maintenance for the PHM consists of little more than daily housekeeping chores. Major FM such as painting and chipping is performed by the MLSG. The weekly hours for FM were determined as follows:

1. FM tasks were identified by interviewing members of the prototype.
2. The time to perform each task was standardized in accordance with a prescribed Navy Standard Work Rate Assumption (from OPNAV instructions [14] for each task as a function of space size or number of units (i.e., sinks, ladders, etc.).
3. The weekly FM man-hours per space was computed by multiplying the task action time by the frequency of that action per week.
4. The grand total of 30.59 hours is the sum of the weekly FM times for each space. Table A4 summarizes FM man-hours by space.

E. UTILITY TASK AND EVOLUTION (UT)

This category accounts for the man-hours spent performing special details while underway. Of all the special details (such as man overboard, low-visibility operations, towing, etc.) only two, the Special Sea and Anchor Detail and Replenishment at Sea are performed with sufficient

TABLE A4

FM WEEKLY WORKLOAD BY SPACE

SPACE	WEEKLY HOURS 5 DAYS	2 DAYS	TOTAL
Pilot House	1.336	.535	1.871
Damage Control & EOS	.303	.121	.424
Conning Platform	1.46	.145	1.605
Crew Lounge	.981	.393	1.374
CIC	.874	.350	1.224
CPO Living Space	1.334	.534	1.868
Communication Room	.286	.115	.401
#1 Crew Living	.995	.398	1.393
#2 Crew Living	1.178	.471	1.649
Deck House Passageway	.363	.145	.508
Electronic Equipment Room	.365	.146	.511
Commanding Officer Stateroom	1.044	.418	1.462
Open Deck	3.135	1.255	4.390
Head Crew	5.431	2.172	7.603
Crew & CPO Mess	2.196	.878	3.074
Wardroom	.43	.172	.602
Passageway #1	.034	.014	.048
Passageway #2	.902	.361	1.263
Passageway #3	.101	.041	.142
Galley	3.839	1.536	5.375
Officer Bunkroom	1.866	.747	2.613
Head Officer & CPO	2.134	.854	2.988
TOTALS	30.587	11.801	42.388
	(At-sea: PHM crew)	(MLSG resposi-bility)	

time consumption or frequency to require accounting of time for the purpose of computing required man-hours. These details take place concurrently with operational watchstanding. Therefore, the man-hours allocated to this category apply only to those personnel who are not on Condition III watch during the special detail. Watch-stander time has already been accounted for in a separate category.

The following subparagraphs account for the UT time category:

1. Special Sea and Anchor Detail is an all-hands evolution. Table A5 shows the time spent by the additional nine crewmembers who are not on watch while completing one getting away and one docking.
2. Replenishment at Sea is also an all-hands evolution. The hours allocated to the Replenishment at Sea Detail depends upon the frequency of refueling during a weekly mission. Since this figure is likely to vary, a weekly average of two underway fuelings is assumed based on a 120-hour mission with approximately 11.2 hours foilborne. The time spent on each refueling is a function of a standard pumping rate of 16,000 gallons per hour with a $2\frac{1}{2}$-inch hose connection. Replenishment at Sea weekly hours are summarized in Table A6.

TABLE A5

WEEKLY HOURS REQUIRED FOR ONE GETTING UNDERWAY DETAIL AND ONE DOCKING DETAIL PER FIVE-DAY MISSION

STATION MANNED	GET READY	EXECUTE DETAIL	COMPLETION	TOTAL
1. Forward - In Charge	0.434	0.50	0.40	1.334
2. Forward	0.434	0.50	0.40	1.334
3. Forward	0.434	0.50	0.40	1.334
4. Bridge	0.434	0.50	0.40	1.334
5. Lee Helmsman	0.434	0.50	0.40	1.334
6. E.O.S. Log	0.434	0.50	0.40	1.334
7. Aft - In Charge	0.434	0.50	0.40	1.334
8. Aft	0.434	0.50	0.40	1.334
9. Aft	0.434	0.50	0.40	1.334
TOTAL WEEKLY MAN-HOURS	3.906	4.50	3.60	12.006

TABLE A6

REPLENISHMENT AT-SEA (REFUELING) DETAIL WORKLOAD ANALYSIS

STATION MANNED	WEEKLY HOURS REQUIRED FOR TWO (2) REFUELINGS			
	GET READY	EXECUTE DETAIL	COMPLETION	TOTAL
1.Bridge Signalman	0.434	0.98	0.368	1.782
2.Fueling Station Signalman	0.434	0.98	0.368	1.782
3.Rig Captain	0.434	0.98	0.368	1.782
4.Sound Powered Phone	0.434	0.98	0.368	1.782
5.Sound Powered Phone	0.434	0.98	0.368	1.782
6.Fueling Station	0.434	0.98	0.368	1.782
7.Fueling Station	0.434	0.98	0.368	1.782
8.Fueling Station	0.434	0.98	0.368	1.782
9.E.O.S. Pump Control	0.434	0.98	0.368	1.782
TOTAL WEEKLY MAN-HOURS	3.906	8.82	3.312	16.038

The total UT man-hour workload for PHM is 28.044 hours per week. The non-watchstanders (the radioman and the mess management specialist) are allocated UT for each detail. The watchstanders are each assumed to be off watch for half the UT details and on watch (operational manning hours) for the other half. Therefore, watchstanders are allocated UT man-hours for only half of the UT details. Equitably distributing this workload, each watchstander is allocated 1.476 UT weekly hours and each non-watchstander is allocated 2.952 UT weekly man-hours.

F. ADMINISTRATIVE AND SUPPORT MANNING (A/S)

The PHM lacks space and facilities for complete administrative services such as postal office, personnel office, disbursing, medical, etc. Most of these functions are performed by the MLSG. Very little administrative and support man-hours are spent by other than the mess management specialist and the radioman. A/S hours for the mess management specialist, radioman and watchstanders were estimated by interviewing the crew of the prototype and are summarized in Tables A7 through A9.

G. SERVICE DIVERSION AND TRAINING ALLOWANCE (SD)

Service Diversion and Training consists of quarters, award ceremonies, departmental training, et cetera. Man-hours for this category is much less than is common on traditional Navy ships. In accordance with a special

TABLE A7

ADMINISTRATIVE AND SUPPORT REQUIREMENTS: SUPPLY (FOOD SERVICE) SUPPORT

TASK	WEEKLY HOURS MESS ATTENDANT
1. Plan daily work	1.00
2. Make Coffee/Clean Coffee Pot	5.00
3. Set up mess tables	1.50
4. Cook breakfast.	5.00
5. Prepare Menu	1.00
6. Prepare stores inventory	2.00
7. Prepare daily subsistance reports	5.00
8. Prepare noon meal	5.00
9. Prepare evening meal	5.00
10. Clean Galley	2.50
11. Store leftover food	2.50
12. Review menu, break out supplies	1.50
13. Break out any provisions	2.00
14. Wash dishes	2.00
15. Stow dishes	2.50
ADMINISTRATIVE AND SUPPORT WEEKLY HOURS ALLOCATED TO MS2	43.50

TABLE A8

ADMINISTRATIVE AND SUPPORT REQUIREMENTS
COMMAND (COMMUNICATOR) SUPPORT

TASK	WEEKLY HOURS COMMUNICATOR
1. Plan work	1.00
2. Process special request chits	.20
3. Monitor performance of personnel operating communications equipment	15.00
4. Monitor performance of equipment	15.00
5. Manage communication traffic	2.50
6. Monitor circuitry engaged in transmission	2.50
7. Prepare stub requisitions	.20
8. Maintain publications and documents	1.25
9. Record and file electronic communications	2.50
10. Inspect equipment	2.50
11. Manage and control communications classified documents	1.25
ADMINISTRATIVE AND SUPPORT WEEKLY HOURS ALLOCATED TO RM1	43.90

TABLE A9

ADMINISTRATIVE AND SUPPORT REQUIREMENTS:

ADMINISTRATIVE (PHM AT-SEA) SUPPORT

TASK	WEEKLY HOURS PER DEPARTMENT OPERATIONS	WEAPONS	ENGINEERING
1. Perform departmental training	.20	.20	.20
2. Process stub requisition chits	.20	.20	.20
3. Maintain publications	.20	.20	.20
4. Maintain charts	.30	-	-
5. Process special request chits	.10	.10	.10
6. Maintain files	.10	.10	.10
7. Plan & assign work to subordinates	2.50	1.00	.50
8. Check work of subordinates	.30	.30	.30
9. Conduct enlisted performance evaluations	.20	.20	.20
10. Prepare/update watch quarter and station bill	.10	.10	.10
11. Administer personnel qualification standards	.10	.10	.10
12. Instruct subordinates in all applications of safety precautions	.20	.20	.20
13. Maintain department files, training data, space and equipment logs	.20	.20	.20
14. Attend briefings	.10	.10	.10
15. Review & route instructions and notices	.10	.10	.10
16. Control & supervises handling and submission of all forms and reports originating within the department	.20	.20	.20
17. Draft/edit correspondence	.10	.10	.10
18. Counseling personnel	.10	.10	.10
19. Maintain Navigation Log	2.50	-	-
20. Supervise maintenance, preservation & cleanliness of all assigned spaces	.40	.40	.40
21. Review maintenance records	.10	.10	.10
22. Review weapons orders and directives	-	.10	-
23. Perform department PO duties	.10	.10	.10
24. Prepare fuel & daily water report	-	-	.10
25. Prepare chemicals for water test	-	-	.10
26. Test fuel	-	-	.10
27. Make log entries	.20	.20	.20
TOTALS	8.60	4.40	4.10

(GRAND TOTAL = 17.10)

OPNAV letter, this allowance has been set at two hours per week for each crew member.

H. STANDARD NAVY WORKWEEK AFLOAT CONSTRAINT

The standard workweek afloat [15] prescribes the maximum weekly hours for enlisted watchstanders at sea as 74 hours and 66 hours for non-watchstanders. The work-week may be less than those amounts but should not exceed them unless compelled by emergency or battle conditions.

For the PHM crew, the standard workweek is completed during its five-day mission. There is no in-port watch-standing or workload requirement except during scheduled maintenance and overhaul periods. Table A10 gives the breakdown of both the Standard Navy Workweek and the PHM version of the Navy Standard which represents the upper bound on weekly man-hours assuming Condition III.

I. WORKLOAD SUMMARY

Table All summarizes the man-hours by category discussed previously. Note that a standard 20% productive allowance to account for inefficiencies usually experienced by shipboard workers has been included. Also note that the two hours per man for Service Diversion and Training has not yet been included because the total number of personnel or the need for additional billets has not been established at this point in the analysis.

TABLE A10

NAVY STANDARD AND PHM UNIQUE WORKWEEKS AFLOAT

	WATCHSTANDER		NON-WATCHSTANDER	
NAVY STANDARD				
1. Total weekly hours available (7 days x 24 hours/day)		168		168
LESS:				
2. Sleep (7 days x 8 hours/day)	56		56	
3. Messing(6 work-days x 2 hrs/day)	12		12	
4. Personal needs(6 wk days x 3 hrs/day)	18		18	
5. Sunday Free Time	8		16	
		94		102
6. Available for Assigned Work		74		66
PHM FIVE-DAY MISSION				
1. Total weekly hours available (5 days x 24 hours/day)		120		120
LESS:				
2. Sleep (5 days x 8 hours/day)	40		40	
3. Messing (5 days x 2 hours/day)	10		10	
4. Personal needs*	0		4	
5. Sunday Free Time*	N/A		N/A	
		50		54
6. Available for Assigned Work		70		66

TABLE A11

GROSS PHM WEEKLY WORKLOAD MAN-HOURS (AT-SEA)

Operational Manning (15 watchstanders x 60.00 hours per week)	= 900.00 hours
Maintenance Manning	
Preventive Maintenance (PM)	= 23.50 hours
Make Ready and Put Away (MR/PA) (30% of PM)	= 7.05 hours
Corrective Maintenance (CM)	= 12.50 hours
Facility Maintenance (FM)	= 30.59 hours
Utility Task and Evolution Manning (UT)	= 28.04 hours
Administrative and Support Manning (A/S)	= 104.50 hours
Productive Allowance (20% of PM, MR/PA, CM, FM, UT and AS)	= 41.19 hours
GROSS PHM WEEKLY WORKLOAD*	=1147.37 hours

*Not including the service diversions and training (SD) allowance of 2.00 hours per billet.

Table A12 indicates that 15 watchstanders and two non-watchstanders provide enough man-hours to accomplish all tasks even after including the SD allowance.

The final step in the manning document preparation process is the allocation of the man-hours in each category. Priority is given to watchstanding hours and maintenance hours requiring higher skill levels. Other tasks are allocated equitably being mindful not to exceed the PHM version of the Navy standard of 70 hours for watchstanders and 66 hours for non-watchstanders. Allocation of all weekly hours is shown in Table A13.

J. OFFICER MANNING

Man-hour breakdown for officers is not a part of this analysis, but an officer billet summary is shown in Table A14. Officer manning for PHM was the result of the combination of a functional analysis of the operational requirements for fighting the ship and responsibilities and duties directed by OPNAV regulations [16].

TABLE A12

DETERMINATION OF QUANTITATIVE PHM ENLISTED MANNING REQUIREMENTS

1.	Gross PHM weekly workload (not including SD allowance)	=	1147.37 hours
2.	Number of watchstanders (15) x PHM unique workweek afloat for watchstanders (70.00 hrs)	=	1050.00 hours
3.	Workload to be assumed by non-watchstanders	=	97.37 hours
4.	Minimum number of non-watchstanders required to meet workload requirements (2) times PHM unique workweek afloat for non-watchstanders (66.00 hours)	=	132.00 hours
5.	Workload to be assumed by non-watchstanders (line 3. above)	=	97.37 hours
6.	Number of available man-hours remaining	=	34.63 hours
7.	Service Diversions and Training Allowance requirements: 2.00 SD hours per enlisted watchstander and non-watchstander billet (2.00 hours x 17 enlisted)	=	34.00 hours
8.	Available hours in excess of workload		0.63 hours

SHIP MANNING REQUIREMENTS ANALYSIS CHART WEEKLY HOURS (At-Sea)

BILLET IDENTIFICATION				OPERATIONAL MANNING REQUIREMENTS			MAINTENANCE MANNING REQUIREMENTS				OTHER REQUIREMENTS			ALLOWANCES		TOTAL WEEKLY HOURS
BILLET NUMBER	BILLET TITLE	RATE	NEC	CONDITION STATION I	CONDITION STATION III	OPER MAN	PM	MI/FA 30%	CM	FM	UTIL TASKS	ADMIN SUPP	CUST SUPP	PROD 20%	SO & T	
OP-101	Quartermaster	QMC	9539	CIC-Navigator	Bridge-OOD	60.00					1.48	5.19		1.33	2.00	70.00
OP-102	Operations Specialist I	OS1	0341	CIC-DRT Plotter	CIC-Navigator	60.00				1.19	1.48	4.00		1.33	2.00	70.00
OP-103	Operations Specialist II	OS2	0341	CIC-Surface Det. Tracker	CIC-Navigator	60.00	0.33	0.10		4.76	1.48			1.33	2.00	70.00
OP-104	Electronics Warfare Technician	EW3	17XX	CIC-ESM Operator	CIC-ESM Operator	60.00				5.19	1.48			1.33	2.00	70.00
OP-105	Radioman	RM2	2313/9539	CIC-Communicator			1.00	0.30	0.50	4.68	2.95	43.90		10.67	2.00	66.00
OP-201	Boatswain's Mate	BM2	9539	Bridge-Helmsman	Bridge-Helmsman	60.00	1.00	0.30		3.39	1.48			1.23	2.00	69.40
OP-202	Mess Managment Specialist	MS2	3528	CIC-Vertical Plotter						6.88	2.95	43.50		10.67	2.00	66.00
W-101	Gunner's Mate	GMG1	0878 9598	Weapons Control Gun Captain/Load.	Bridge-Helmsman	60.00	1.00	0.30		1.89	1.48	2.00		1.33	2.00	70.00
W-102	Fire Control Technician I	FTG1	1101	CIC-Air Target Operator	CIC-Air Target Operator	60.00	1.00	0.30		0.68	1.48	3.21		1.33	2.00	70.00
W-103	Fire Control Technician II	FTG2	1101	CIC-Surface Target Operator	CIC-Air Target Operator	60.00	2.50	0.75	1.25	0.69	1.48			1.33	2.00	70.00
W-104	Electronics Technician	ET2	1572	Bridge-Lookout/Phone Talker	CIC-Surface Detection Tracker	60.00	1.50	0.45	1.50	1.24	1.48	0.50		1.33	2.00	70.00

TABLE A13

SHIP MANNING REQUIREMENTS ANALYSIS CHART WEEKLY HOURS (At-Sea)

BILLET IDENTIFICATION				OPERATIONAL MANNING REQUIREMENTS			MAINTENANCE MANNING REQUIREMENTS				OTHER REQUIREMENTS			ALLOWANCES		TOTAL WEEKLY HOURS
BILLET NUMBER	BILLET TITLE	RATE	NEC	CONDITION STATION I	CONDITION STATION III	OPER MAN	PM	MR/PA 30%	CM	FM	UTIL TASKS	ADMIN SUPP	CUST. SUPP.	PROD 20%	SD & T	
E-101	Chief Engineman	ENC	4111	EOS-Operator	EOS-Operator	60.00	2.50	0.75	1.25		1.47	0.70		1.33	2.00	70.00
E-102	Propulsion Technician	EN1	43XX 9555	Damage Control Repair Party Leader	EOS-Operator	60.00	2.46	0.74	1.50		1.47	0.50		1.33	2.00	70.00
E-103	Auxiliaries Technician	EN3	4111	Damage Control Repair Party	EOS-Assistant Operator	60.00	2.76	0.83	1.61		1.47			1.33	2.00	70.00
E-104	Electrician's Mate	EM2	4111	EOS-Assistant Operator	EOS-Assistant Operator	60.00	2.33	0.70	1.66		1.47	0.50		1.33	2.00	69.99
E-105	Interior Communications Electrician	IC2	4117/ 4724	Damage Control Repair Party	CIC-Surface Det. Tracker	60.00	2.41	0.72	1.56		1.47	0.50		1.33	2.00	69.99
E-106	ESM Operator	ICFN		Weapons Control Ammo Handler	CIC-ESM Operator	60.00	2.71	0.81	1.67		1.47			1.33	2.00	69.99

TABLE A13 (CONT.)

OFFICER BILLET/STATION SUMMARY

BILLET NUMBER	TITLE	RANK	DESIG NOBC	OPERATIONAL MANNING		FUNCTIONAL MANNING		
				CONDITION I STATION	CONDITION III STATION	PRIMARY	SECONDARY	TERTIARY
0-101	Commanding Officer	LCDR	(1110) 9222	Bridge/ CIC	N/A	Commanding Officer	N/A	N/A
0-102	Executive Officer	LT	(1110) 9228/ 9274	CIC-TAO	CIC-TAO	Executive Officer	Operations Officer	Administrative Officer
0-103	Weapons Officer	LTJG	(1110) 9258 9216	CIC-TAO	CIC-TAO	Weapons Officer	Department Administration	N/A
0-104	Engineering Officer	LTJG	(1110) 9364	Bridge-OOD	Bridge-OOD	Engineering Officer	Department Administration	N/A

TABLE A14

APPENDIX B

PHM TRAINING REQUIREMENTS

Appendix A discusses the rationale for the number of personnel to man the PHM as well as for ratings and skill levels required. Once the ship's manning has been established it is necessary to determine how these personnel will be trained to operate and maintain the ship.

A. TRAINING CONCEPT

The uniqueness of the PHM which distinguishes it from traditional combat vessels requires a correspondingly unique training concept. As the product of a NATO design the ship contains equipments not found on other Navy vessels. The reduced manning concept which was a result of the operational and maintenance concepts requires highly skilled personnel who are capable of operation as well as repair of the equipment. As forecasted early in the conceptual phase, more training is anticipated to be required for PHM crew members than for crew members on other Navy ships. The following information taken from the Navy Training Plan for the PHM [4] discusses the training goals and methods planned for accomplishing those goals.

"Existing Navy training courses will be used to the maximum extent possible to train PHM personnel. Training

requirements that cannot be satisfied by existing Navy schools will be met by contractor training for the initial crews and by formal training and on-board training under the cognizance of the Squadron Commander." The manning document for the MLSG includes instructor billets to provide for this additional training.

Training for the crew falls into two broad categories:

1. Prerequisite Training

Prerequisite training consists of both professional and technical courses normally completed in preparation for assignment to a billet. Examples are: a PXO (Prospective Executive Officer) course for officers, and an NEC awarding course for enlisted personnel or course required for performance in an identified PHM billet for which an NEC is not required.

In general, these training requirements are generated by the equipment maintenance or operational requirement or by watch station assignments. These prerequisite training requirements will be met by existing Navy Schools and will be received prior to undertaking PHM unique training.

2. "PHM Unique" Training

Unique training consists of the courses specifically designed to prepare personnel to perform operation and maintenance functions unique to PHM equipment. There

are no established Navy schools for this type of training due to previous lack of requirement for them, nor are Navy schools expected to be established for PHM equipment because of the relatively small number of personnel involved. The training must nonetheless be accomplished. Two approaches to accomplish this training will be utilized: factory training and on-board training under the cognizance of the PHM Squadron Commander.

Factory training by the Boeing Company provides the original body of knowledge and skills to selected initial crewmembers and MLSG instructor personnel on a one-time basis. Replacement personnel are trained either on-board by personnel being relieved or formally by the instructors at the MLSG training division. The success of this training approach depends upon the Navy's detailing ability to provide contact reliefs, especially for the instructors, to preserve the body of knowledge first acquired from contractor training. In the case of gapped billets, the knowledge could only be restored by additional (and costly) contracted training arrangements with Boeing.

B. TRAINING COURSE REQUIREMENTS

Training requirements were established by an analysis of the operational and maintenance tasks required by each billet. Personal interviews with prototype crewmembers were extensively used. The content of Navy courses already in existence was also reviewed. Whenever a training

requirement could be satisfied by one of these schools, that school became prerequisite training for the billet. All other training requirements not satisfied in this manner were incorporated into a formal training course to be conducted locally at the MLSG or at the Boeing plant for the initial crews.

Table B1 lists by billet the prerequisite and PHM unique training courses deemed necessary by the project manager for the effective utilization of the ship. The list comes from the 1976 version of the PHM Navy Training Plan [4] which was approved by the Office of the Chief of Naval Operations. Approval of the training plan does not guarantee eventual funding for each course identified; it merely validates the need. Actual funding approval depends largely upon the priority placed on each requirement by the Chief of Naval Education and Training during the Program Objective Memorandum (POM) submission process. The items marked with an asterisk (*) were eventually not funded, and the crew will not receive these prerequisite courses. The reasons for courses not being funded are discussed in the "Analysis" chapter.

C. TRAINING EQUIPMENT AND DEVICES

Training equipments are actual hardware equipments such as an actual radar or engine which is used for training. Training devices are simulators or mockups of the actual equipment used in place of the actual equipment for reasons of safety or cost.

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
PHM Commanding Officer LCDR 1110/9234	Surface Warfare Officer-Advanced Command	7 wks	Familiarization	1 wk
			Navigation/Signaling	3 wks
	PCO/PXO Gas Turbine Engineering Equipment Familiarization	.8 wks	Ship Control System	1 wk
			Command & Control	3 wks
	Human Resources Management	1 wk	Underway Training	3 wks
	*Launching System MK 33,34 Operation	.2 wk		
PHM Executive Officer LT 1110/9228	Surface Warfare Officer-Advanced Course - Executive	7 wks	Familiarization	1 wk
			Navigation/Signaling	3 wks
	PCO/PXO Gas Turbine Engineering Equipment	.8 wk	Ship Control System	1 wk
	Human Resources Management	1 wk	Command & Control	3 wks
	FFG-7 Weapons System PCO/PXO Briefing	1 wk	Underway Training	3 wks
	*Launching System MK 33,34 Operation	.2 wk		
PHM Weapons Officer LTJG 1110/9258	*Surface Warfare Officer School	16wks	Familiarization	1 wk
	FFG-7 Weapons Systems Officer Course	6 wks	Navigation/Signaling	1 wk
			Ship Control System	1 wk
	Launching System MK 33,34 Operation	1 wk	Command & Control	3 wks
			Underway Training	3 wks

TABLE B1

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
PHM ENGINEERING OFFICER LTJG 1110/9364	*Surface Warfare - Basic	16 wks	Familiarization	1 wk
	Marine Gas Turbines - Basic	6 wks	Auxil. Systems	3 wks
	Propulsion Systems Indoctrination	2 wks	Electrical Plant	2 wks
			Ship Control System	1 wk
	LM-2500 Gas Turbine Maintenance	5 wks	Propulsion & EOS	3 wks
	Vibration Analysis	1 wk	Command & Control	3 wks
	Launching Systems MK 33,34 Operation	.2 wk	Underway Training	3 wks
QMC 0000			Familiarization	1 wk
			Navigation/Signaling	3 wks
			Ship Control System	1 wk
			Command & Control	3 wks
			Underway Training	3 wks
ET2 1438	*L-L Key Teletype Maint.	3 wks	Familiarization	1 wk
	*Crypto Equip TSEC/KY-8 Maint.	9 wks	Navigation/Signaling	3 wks
	*Vocorder Group TSEC/HY-2	6 wks	Ship Control System	1 wk
	TSEC/KW-7 Crypto Maint	7 wks	Command & Control	3 wk
	AN/SRN-17 OMEGA	1 wk	Underway Training	

TABLE B1 (CONT.)

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
OS1, OS2 0341	* Naval Warfare Operations Specialist - Advanced	10 wks	Familiarization	1 wk
			Navigation/Signaling	3 wks
	*Launching Systems MK 33,34 Operations	.2 wk	Ship Control System	1 wk
			Command and Control	3 wks
			Underway Training	3 wks
RM2 2313,2346	Radioman Class B	18 wks	Familiarization	1 wk
	Teletype Repair	3 wks	Command and Control	3 wks
			Underway Training	3 wks
EW3 0000	*Launching Systems MK 33,34	.2 wk	Familiarization	1 wk
			Command And Control	3 wks
			Underway Training	3 wks
FTG1, FTG2 1101	*Digital Techniquies & Principles	3wks	Familiarization	1 wk
			Ship Control System	1 wk
	*AN/UYK-7 Maint	4 wks	Command and Control	3 wks
	GMFCS MK 92 Maint	20 wks	Underway Training	3 wks

TABLE B1 (CONT.)

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
GMG 1 0878, *9598	HARPOON - Weapons System Cannister Configuration, Operation and Maint.	.6 wk	Familiarization	1 wk
			Electrical Plant	2 wks
	OTO MELARA Gun 76MM, MK 75 Maint.	10 wks	Ship Control System	1 wk
			Damage Control Team	1 wk
	*Disaster Preparedness	4 wks	Underway Training	3 wks
ENC, EN3 4111	Basic Electricity and Electronics	8 wks	Familiarization	1 wk
			Electrical Plant	2 wks
	Marine Gas Turbines - Basic	6 wks	Propulsion Plant & EOS	3 wks
	Propulsion Systems Indoctrin.	2 wks	Auxiliary Systems	3 wks
	LM 2500 Gas Turbine Maint.	5 wks	Underway Training	3 wks
EN1 4315,9555	Engineman - General Motors Diesel Technician	12 wks	Familiarization	1 wk
			Auxiliary Systems	3 wks
	Damage Control Repair Party Leader	3 wks	Propulsion Plant & EOS	3 wks
			Underway Training	3 wks

TABLE B1 (CONT.)

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
MM2 4111	Marine Gas Turbines - Basic	6 wks	Familiarization	1 wk
	Propulsion Systems Indoctrination	2 wks	Electrical Plant	2 wks
			Propulsion Plant & EOS	3 wks
	Basic Circuit Concepts for Gas Turbine Controls	2 wks	Damage Control Team	1 wk
			Underway Training	3 wks
IC2 4117,4775,4724	Digital Techniques and Principles	5 wks	Familiarization	1 wk
			Navigation/Signaling	3 wks
	DRAI/DRT Maint MK 9 MOD 4/MK 6 MOD 4B	3 wks	Electrical Plant	2 wks
	Marine Gas Turbines - Basic	6 wks	Propulsion Plant and EOS	3 wks
	Propulsion Systems Indoctr.	2 wks	Underway Training	3 wks
	Basic Circuit Concepts for Gas Turbine Controls	2 wks		
	Gyrocompass Technician - Electrical	4 wks		
ICFN 0000/4117	Interior Communications Electrician - Class A	9 wks	Familiarization	1 wk
			Navigation/Signaling	3 wks
			Electrical Plant	2 wks
			Underway Training	3 wks

TABLE B1 (CONT.)

SUMMARY OF REQUIRED TRAINING COURSES

BILLET TITLE RANK/RATING DESIGNATOR/NOBC/NEC	PREREQUISITE TRAINING	LENGTH	PHM UNIQUE TRAINING	LENGTH
BM2 0000	Disaster Recovery Training First Aid and Personnel Protection	.6wk	Familiarization Underway Training	1 wk 3 wks
MS2 3529	Mess Management Specialist Class C Management Principles	9 wks	Familiarization Underway Training	1 wk 3 wks

TABLE B1 (CONT.)

Training equipments and devices are extremely important to the success of the PHM training program due to the low manning concept. Each crew member has to know how to perform his job before the ship gets underway. There is not enough space aboard to carry personnel in a training status for more than one day. It is necessary that the crew receive hands-on operational and maintenance training through maximum use of training equipments and devices to minimize the need for on-board training.

The Project Office requested the training equipments and devices listed in Table B2 by letter in 1978 before including them in the Navy Training Plan. The notation "not supported by CNO" indicates that the equipments were not supported by the OP-39 surface warfare sponsor of the program and therefore are not likely candidates for POM-81 funding. Support and funding rationale for these items is discussed in the "Analysis" chapter.

TABLE B2

TRAINING LOGISTIC SUPPORT REQUIREMENTS

A. TRAINING EQUIPMENTS

EQUIPMENT	LOCATION	FUNDING STATUS
ME-831 SSPU AIRESEARCH Gas Turbine Maintenance Trainer	Great Lakes	Not Supported By CNO
HECI Harpoon Engagement Course Indicator	San Diego	Not Supported By CNO
Automatic Control System	MLSG	Not Supported By CNO
(LITEF) Inertial Gyrocompass	MLSG	Funded POM 80
SPS-63 Surface Search Radar	MLSG	Not Supported By CNO

B. TRAINING DEVICES

DEVICE	LOCATION	FUNDING STATUS
Engineering Operating Station (EOS) Simulated Gas Turbine Trainer	Great Lakes	Not Supported By CNO
EOS Panel Mockup	MLSG	Not Supported By CNO
Main Propulsion Pump Cutaway Mockup	MLSG	Not Supported By CNO
MTU Diesel Head with Valve Train Cutaway Mockup	MLSG	Not Supported By CNO
Bow Thruster Motor, Cutaway Mockup	MLSG	Being Considered For Funding
Bridge Console Mockup, Navigation	MLSG	Not Supported By CNO
Distilling Plant, Cutaway Mockup	MLSG	Not Supported By CNO
Vickers Hydraulic Trainer	MLSG	Not Supported By CNO
Logic Trainer Electronics, Fire Control	MLSG	Not Supported By CNO

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